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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/009,249	07/02/2002	Donald Dominic Arnone	P/25-271	8638

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EXAMINER	
JOHNSTON, PHILLIP A	

ART UNIT	PAPER NUMBER
2881	

DATE MAILED: 12/16/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)
	10/009,249	ARNONE ET AL.
	Examin r	Art Unit
	Phillip A Johnston	2881

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *44-71* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *44-71* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *02 July 2002* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. §§ 119 and 120

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

13)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

a) ☐ The translation of the foreign language provisional application has been received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

Detailed Action

Claims Rejection – 35 U.S.C. 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 44-71 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 5,939,721 to Jacobsen, in view of Nuss, U.S. Patent No. 5,623,145.

Jacobsen (721) discloses in FIG. 1, a THz imaging apparatus 10 that includes a source 12 of repetitive optical pulses of femtosecond duration, imaging arrangement 14 by which THz radiation is generated, directed at a medium under investigation 16, and detected upon transmission through or reflection by the medium, and analysis circuitry indicated generally at 18. Source 12 may be configured, for example, as a solid state laser like the Ti:Sapphire laser, which has a wavelength near 800 nm and a typical repetition rate of about 100 MHz. Alternatively, source 12 may be configured as a femtosecond Erbium-Doped Fiber Laser operating at a wavelength near 1.5 mμm. In the illustrative embodiment depicted in FIG. 1, imaging arrangement 14

includes an optically gated THz transmitter 20 and an optically gated THz detector 22. A beam splitter (not shown) divides the output of source 12 into two beams, the pulses of which are used to optically gate transmitter 20 and detector 22. A variable delay line 26, varies the optical delay between the respective gating pulses to acquire a sampled replica of the THz waveform.

FIGS. 3A-3E show schematically how THz waveforms may be altered by transmission through an object with different properties. Although this is illustrated by using the example of a transmission geometry, it can easily be appreciated by someone skilled in the art that similar distortions of THz waveforms may occur in reflection. In FIG. 3A, the THz waveform is going through a material with frequency-independent absorption and refractive index, resulting in a returned waveform that is an attenuated replica of the input waveform. As shown in FIG. 3B, high-frequency absorption of the traversed medium leads to selective attenuation of the high-frequency portion of the waveform and consequent broadening of the waveform in the time-domain. In FIG. 3C, the material with frequency-dependent refractive index leads to a "chirped" waveform, in which different frequency components of the waveform travel at different phase velocity, thus leading to a time-dependent frequency variation within the pulse. As shown in FIG. 3D, thickness or index variations of the sample lead to differences in arrival time of the waveform, depending on which portion of the object was traversed by the beam. As shown in FIG. 3E, sharp absorption lines within the spectrum of the THz pulse, such as for polar gases such as water vapor, O_2, HCl

vapor, etc., lead to oscillations at the frequencies of the sharp lines in the trailing part of the pulse.

It is known in the field of THz spectroscopy that information about the complex dielectric constant of the material under investigation can be obtained by comparing the frequency-dependent amplitude and phase of the input and returned waveforms. Heretofore, this has been accomplished by computing the complex Fourier transform of both input and returned waveforms, and dividing the complex Fourier spectrum of the returned waveform by the complex Fourier spectrum of the input spectrum. The complex dielectric constant (absorption coefficient and refractive index) can then be obtained by taking a log of the waveform and dividing the result by the thickness of the medium [Nuss, Orenstein, 1997]. Since many materials have characteristic variations in the frequency dependence of their absorption constant and refractive index over the 100 Hz to few THz frequency range covered by the THz waveform, a comparison of the Fourier spectra of the returned THz waveforms can give an indication of and in some cases uniquely identifies the composition of the object. See Column 5, line 27-67; and Column 6, line 1-33.

Jacobsen (721) also discloses, where only information about the transmissivity or reflectivity of the object is required without spectral resolution such as in package inspection, compression can comprise an integration of the Fourier-transform of the waveform in a certain spectral range to obtain a measure of transmitted or reflected power, or a peak search to obtain the peak signal of the waveform. Where the optical system can focus to a diffraction-limited focal spot, as described in U.S. patent

application 08/711,146, the spot-size will depend inversely on frequency. Advantageously, only a partial integration--over only the high-frequency portion of the THz frequency spectrum--is needed to increase the spatial resolution during T-ray imaging. As an illustration, illustrative FIGS. 4A and 4C show T-ray images of a resolution target over three frequency ranges wherein the T-ray image has been obtained by integrating the THz spectrum over three different frequency ranges (0.1-0.3, 0.3-0.5, and 0.5-0.7, respectively). In each case, the digital signal processor performs a FFT of the waveform and integrates over portions of the magnitude of the FFT. Because the of the capability of the system to focus to a diffraction limited spot, i.e., with a spot size that varies inversely proportional to the frequency, integration over the high-frequency portion of the power spectrum leads to images with better spatial resolution. See Column 6, line 41-65.

Jacobsen (721) further discloses that because THz-TDS is a time-domain technique, another simple yet important compression step is timing extraction, for example by finding the time-delay of the waveforms after passing through materials. This is useful for example in assessing thickness variations, or in determining the position of unknown objects in reflection geometry. As an example, FIG. 6 shows a gray scale T-ray image of a flame, obtained by measuring the difference in arrival time of the focused THz beams through the flame. The DSP was instructed in this case to determine the peak position of the waveform in time and apply a gray scale to the temporal shift of the waveform. Each contour corresponds to a 5 femtosecond incremental shift in time delay. It will be appreciated from FIG. 6 that, although the

duration of the THz pulse is on the order of 1 ps, the position of the peak of the waveform can be determined with an accuracy approaching a few femtoseconds.

In addition to the simple peak-search method to find the temporal position of a THz waveform after transmission or reflection, the inventors have observed that typical THz waveforms have properties that are similar to mathematical wavefunctions called wavelets. Therefore, the inventors have recognized that a constant-scale wavelet analysis can conveniently be used to determine the temporal position of transmitted or reflected waveforms. Unlike the peak-position method, the wavelet analysis method also works in the presence of multiple reflected waveforms, when the temporal position of many, isolated or overlapping THz waveforms has to be found. See Column 7, line 19-49.

Jacobsen (721) as applied above does not disclose the use of a CCD for detecting the transmitted and reflected radiation, as recited in Claims 59 and 69. However, Nuss (145) discloses a focal plane THz detector array that consists of a two-dimensional array of THz dipole antennas (in this case 50 mμm on each side), which are lithographically defined on a low temperature (LT)-GaAs or radiation-damaged Silicon-on-Sapphire (SOS) chip so that the gating time is subpicosecond. MSM photoconductive switches using interdigitated finger contacts are defined between the antenna chip. The size of the interdigitated photoconductive MSM switch is roughly 10 mμm square. Each of the antenna/MSM elements constitutes a THz image pixel. The MSM photoconductive switches are gated by a short optical pulse derived from a beam that covers the entire area of the chip and is focused onto the MSM detectors

using a microlens array. The microlens array and the gate pulse can either come from the same side as the THz radiation (with a beam splitter), or from opposite sides (in this case the THz beam travels through the chip substrates before it is detected by the antennas). Only 1 pJ of readout energy is required for each MSM gate, so that a 10 nJ optical pulse can gate a 100x100 focal plane array. The antenna chip is solder bump-bonded to another chip underneath with one contact on each antenna pad that carries the detected photocurrent off the chip and to the DSP processor. Preferably, the underlying chip contacted by the solder bumps is a CCD array, so that all pixels can be read out sequentially like a video camera. The photogenerated charges are accumulated in the CCD array over many optical pulses before the charge is read out. See Column 4, line 43-67.

Therefore it would have been obvious to one of ordinary skill in the art that the Terahertz imaging apparatus and method of Jacobsen (721) can be modified to use the CCD in accordance with Nuss (145), to provide a gated THz detector .

Regarding Claims 50-58, Jacobsen (721) in view of Nuss (145) does not disclose the use of an emitter with non-linear optical properties, as recited in Claim 50. However, Zhang (416) discloses in FIG. 13 another embodiment of a co-propagating electro-optic sampling apparatus, generally denoted 50, in accordance with the present invention. In this simplified sensor arrangement, the femtosecond optical source is assumed to comprise a Ti:sapphire laser pumped by an Argon ion laser. The terahertz field might be generated from an unbiased GaAs wafer (not shown) with optical incidence at the Brewster angle. See Column 11, line 50-57.

Therefore it would have been obvious to one of ordinary skill in the art that the Terahertz imaging apparatus and method of Jacobsen (721) in view of Nuss (145) can be modified to use the GaAs semiconductor emitter in accordance with Zhang (416), as a femtosecond optical source.

Conclusion

3. Any inquiry concerning this communication or earlier communications should be directed to Phillip Johnston whose telephone number is (703) 305-7022. The examiner can normally be reached on Monday-Friday from 7:30 am to 4:00 pm. If attempts to reach the examiner by telephone are unsuccessful, the examiners supervisor John Lee can be reached at (703) 308-4116. The fax phone numbers are (703) 872-9318 for regular response activity, and (703) 872-9319 for after-final responses. In addition the customer service fax number is (703) 872- 9317.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703 308 0956.

PJ

November 25, 2003

JOHN R. LEE
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2800